Development of Oxide Electrodes of Electrochemical Supercapacitors

Yoshio Takasu,[1] Wataru Sugimoto,[1]
Takeshi Ohnuma,[1] Michihisa Shimizu,[1]
Hiroyoshi Shibutani[1] and Yasuyuki Yamamoto[1]
[1]Shinshu University
Faculty of Textile Science and Technology
3-15-1
Ueda 386-8567
Japan

Development of Oxide Electrodes of Electrochemical Supercapacitors Y. Takasu*, W. Sugimoto, T. Ohnuma, M. Shimizu, H. Sibutani, Y. Yamamoto,Y. Murakami Faculty of Textile Science and Technology, Shinshu University, 3-15-1 Tokida, Ueda 386-8567, Japan E-mail: ytakasu@giptc.shinshu-u.ac.jp

Since oxide electrodes have a potential to give much larger capacitance than carbon electrodes, various kinds of oxide electrodes have so far been examined for the development of supercapacitors. Those oxides are classified as follows: (1) Crystalline oxides and amorphous hydrated oxides, (2) Ruthenium-based oxides and non-ruthenium oxides (inexpensive oxides), (3) DSA-type coating oxides and powder oxides. In this paper, both crystalline oxides of Ru-V-O and Mo-O were examined. The former was investigated by DSA-type and powder methods, and the latter was by a powder method. All the capacitance were determined by cyclic voltammetry in 0.5 M H2SO4 at 25C.

1. DSA-type Ru-V-O/Ti Coating Electrodes1, 2) Titanium rods or plates were dipped into dip-coating solutions of RuCl3 + NH4VO3 + (ethylene glycol + 1060C for 10 min followed by firering at a temperature between 300 and 550C in a preheated furnace for 10 min. The process of dip coating, drying and firering was repeated 10 times. Since the as-prepared oxide layer formed on the Ti substrate was composed of mixed oxide of Rux-Vy-Os and V2O5, the V2O5 was perfectly leached out by acid prior to evaluate the capacitance of the electrodes. The maximum capacitance, 275 F g-1, was obtained at an electrode with a nominal composition of Ru0.4-V0.6-Oz/Ti prepared at 450C. With the surface area of the electrode determined by Xe-BET, the pseudo- capacitance is calculated to be 220 mC cm-2, which is much larger than that of the double layer capacitance of Hg, 20 mC cm-2.

2. Composite Electrodes of Ru-V-O Powder and Carbon By a powder synthesis method, homogeneous Rux-Vy-Oz binary oxide powder with more precise composition than the DSA-type electrodes described above could be prepared. The capacitance of the oxide powder was determined by putting its mixture with PTFE onto a Pt mesh electrode with and without carbon powder. These powder electrodes gave larger pseudo-capacitance than those of the DSA-type coating electrodes as shown in Table1.

3. Composite Electrodes of MoO3 and Carbon Since molybdenum oxide is a semiconductor, it must be assisted with an electro-conducting material when it was used as electrodes of supercapacitors. These authors clarified by an investigation with a model electrode that highly dispersion of MoO3 over carbon support is indispensable for MoO3/carbon composite electrodes; therefore, MoO3 was supported on either activated carbon powder3) or carbon xerogel. Activated carbon powder (Mitsubishi Chemical, 1900 m2 g-1 surface area) or carbon xerogel (764 m2 g-1) prepared by these authors after the method presented by Pekala4) was added to a methanol solution of MoCl3. After drying of the suspension, it was fired in air at 350C. The addition of small amount of MoO3 (1.4 1.6 mass-carbon xerogel (CXG) increased the capacitance of AC and CXG by 3422

Table 1. Specific capacitance of oxide electrodes (F g-1) Method Ru-V-O AC MoO3/AC CXG MoO3/CXG Dip-coating 2752) Powder 576* 132 1773) 179 2185) * The value of 576 F g-1 corresponds to 1220 F g-1-RuO2.

References 1. Y. Takasu et al., J. Eelectrochem. Soc, 144, 2601 (1997). 2. Y. Takasu et al., paper in preparation 3. W. Sugimoto et al., Electrochem. Solid-State Lett. 4, A145 (2001). 4. R. W. Pekala, J. Mater. Sci. 24, 3221 (1989). 5. W. Sugimoto et al., submitted in Electrochem. Solid-State Lett.